KOPIO TN052

FastMC study of interbunch $K_L^0 \to \pi^0\pi^0$ background

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Abstract

The background rate from interbunch $K_L^0 \to \pi^0\pi^0$ decays was studied using the FastMC with the 100×5 mrad^2 aspect ratio.

KOPIO will attempt to exploit a bunched primary beam with bunch spacing of 40 ns. Successful reconstruction of the K_L^0 center-of-momentum system (CMS) places demands on the interbunch extinction rate. In this note the background rates from $K_L^0 \to \pi^0\pi^0$ decays that occur between bunches are compared to the rate from $K_L^0 \to \pi^0\pi^0$ decays in a bunch.

The FastMC with the 100×5 mrad^2 aspect ratio and Zeller's model of the PR is used. The $K_L^0 \to \pi^0\pi^0$ background rates for seven different sets of cuts, designed to map out the signal/background (S/B) to signal contour are compared at 10 ns intervals with respect to the bunch. Two million $K_L^0 \to \pi^0\pi^0$ decays in the region (950,1350) cm were generated. For each of the 9 times with respect to the bunch center, the same two million decays were smeared, reconstructed and analyzed. The photon and charged particle veto rejection is assumed to be the same for bunch and interbunch K_L^0. A reconstructed π^0 from out-of-bunch K_L^0 decay cause the wrong momentum to be assigned to the candidate K_L^0.

Figure 1 shows the absolute rate evaluated at each of the 9 different times with respect to the bunch center. Figure 2 shows the rates for each cut set relative to the bunch center. Only statistical uncertainties are shown.

Figure 3 show the induced bias in the π^0 momentum in the K_L^0 CMS, $P^*(\pi^0)$, for the 9 different times. At -10 ns with respect to the bunch, the induced bias moves the $K_L^0 \to \pi^0\pi^0$ 'even' background into the signal region as clearly demonstrated by the $P^*(\pi^0)$ *vs* $|E^*_{\gamma 1} - E^*_{\gamma 2}|$ distributions in Figure 4. $E^*_{\gamma i}$ is the CMS energy of the i^{th} candidate photon daughter of the π^0.

Although the different cut sets produce different rates, the analysis shows that interbunch events that occur within ± 20 ns of the bunch are the most pernicious and produce rates comparable to or exceeding the bunch rate. Interbunch extinction of $r = 10^{-2}$/ns or better will be needed to suppress interbunch $K_L^0 \to \pi^0\pi^0$ rates to levels below the bunch rate where r is the number of interbunch K_L^0 per nanosecond divided by the number of K_L^0 in the bunch. Other backgrounds, that are also heavily suppressed by $P^*(\pi^0)$ cuts, such as $K_L^0 \to \pi^0\pi\pi$, probably necessitate greater total interbunch extinction rates.

Thanks to Laur Littenberg for suggesting this study and to Laur and Michael Sivertz for providing comments and suggestions.

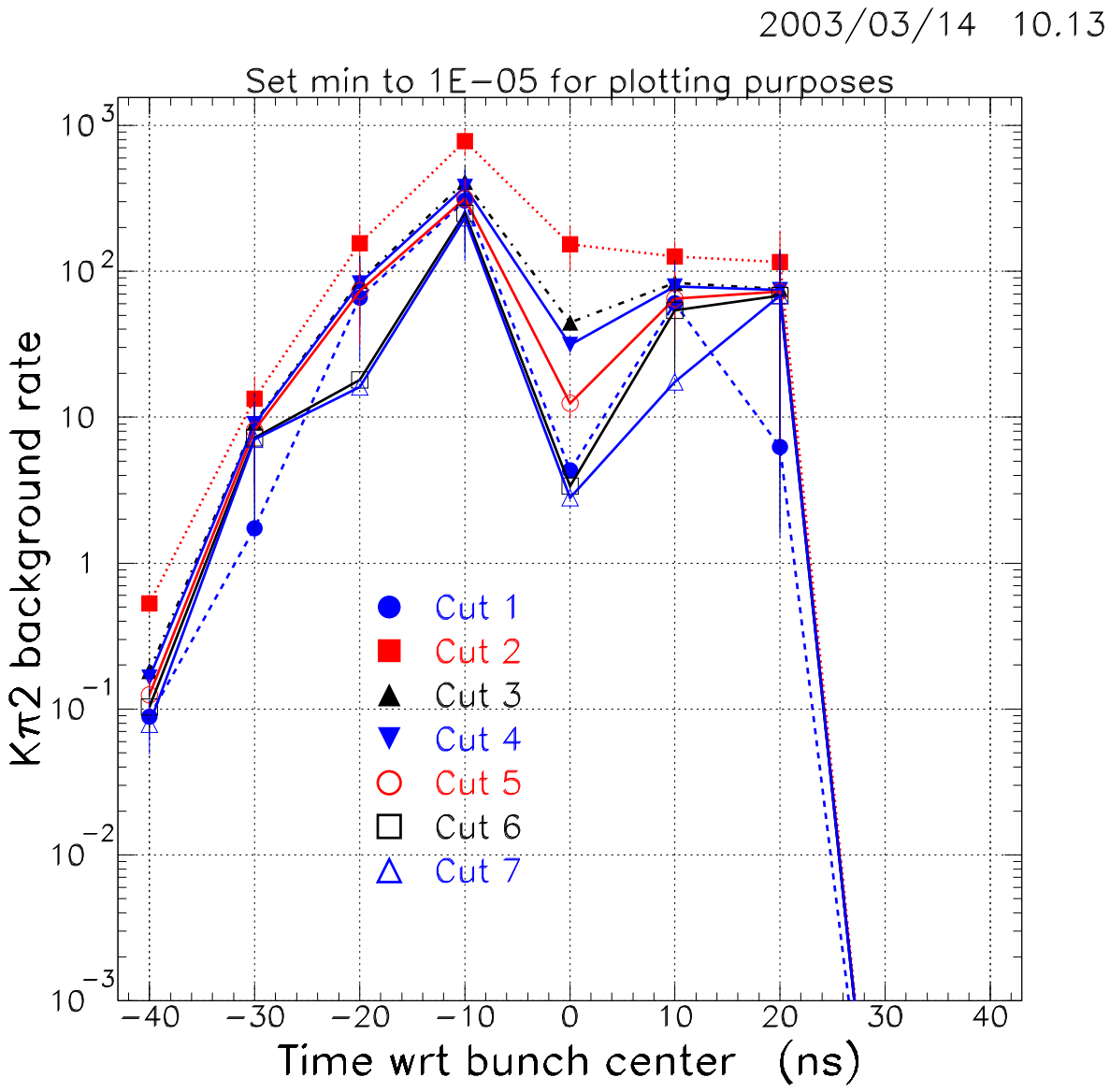

Figure 1: Absolute $K_L^0 \to \pi^0\pi^0$ background rates with respect to the bunch center.

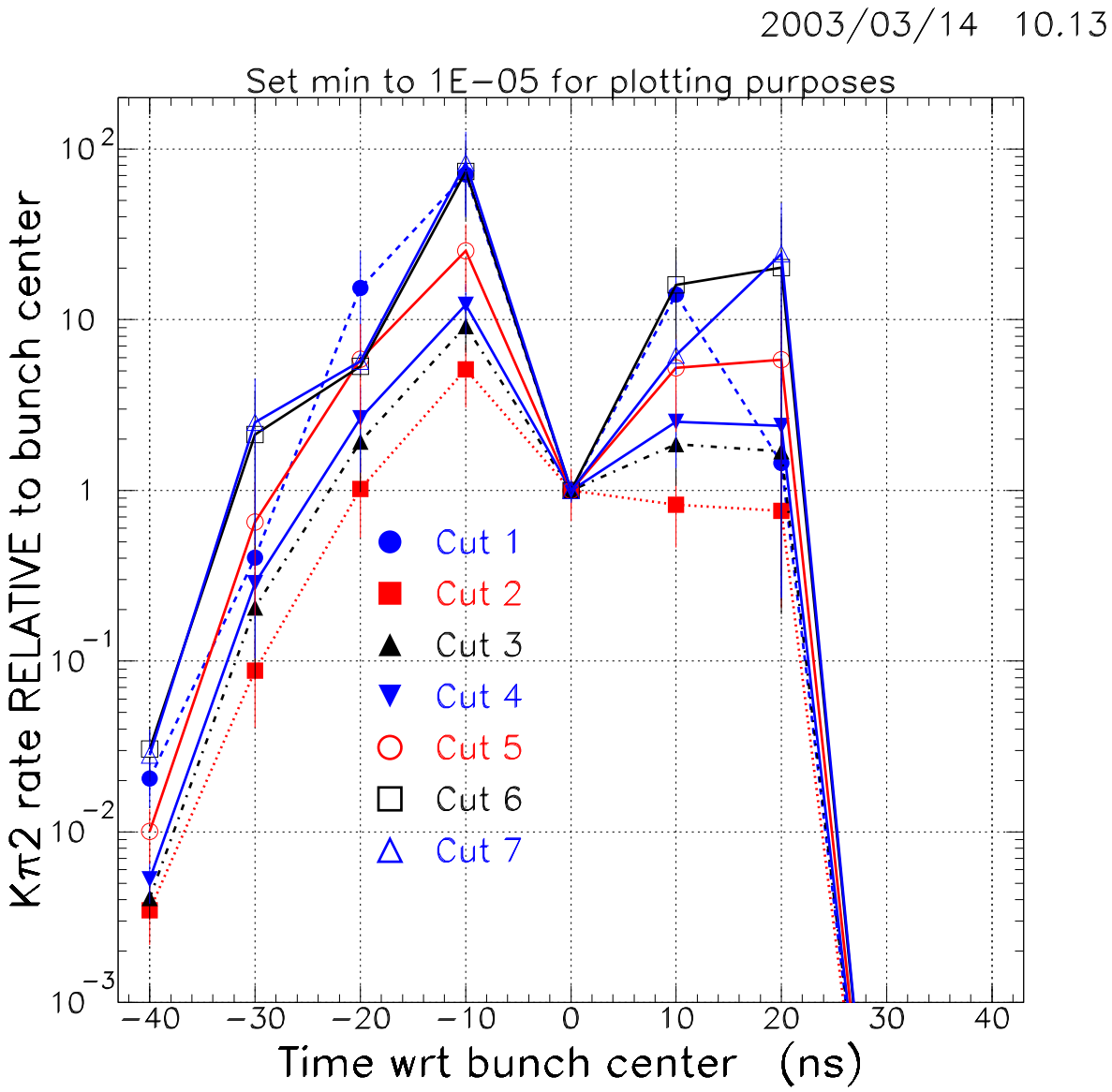

Figure 2: Relative $K_L^0 \to \pi^0\pi^0$ background rates with respect to the bunch center.

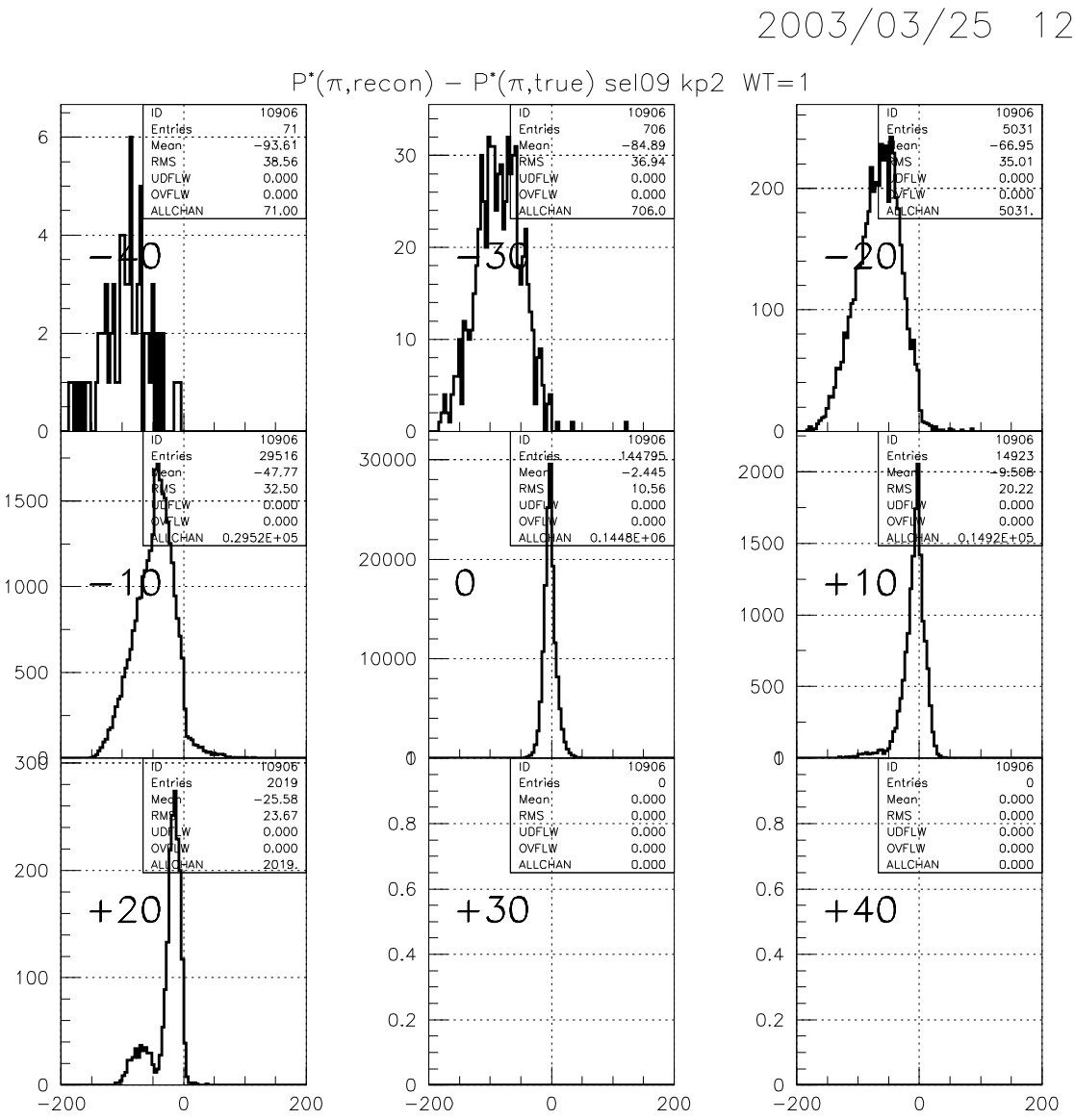

Figure 3: The measured bias in $P^*(\pi^0)$, for the 9 different times with respect to the bunch. The large bold numbers superimposed on each plot give the time relative to the bunch in ns.

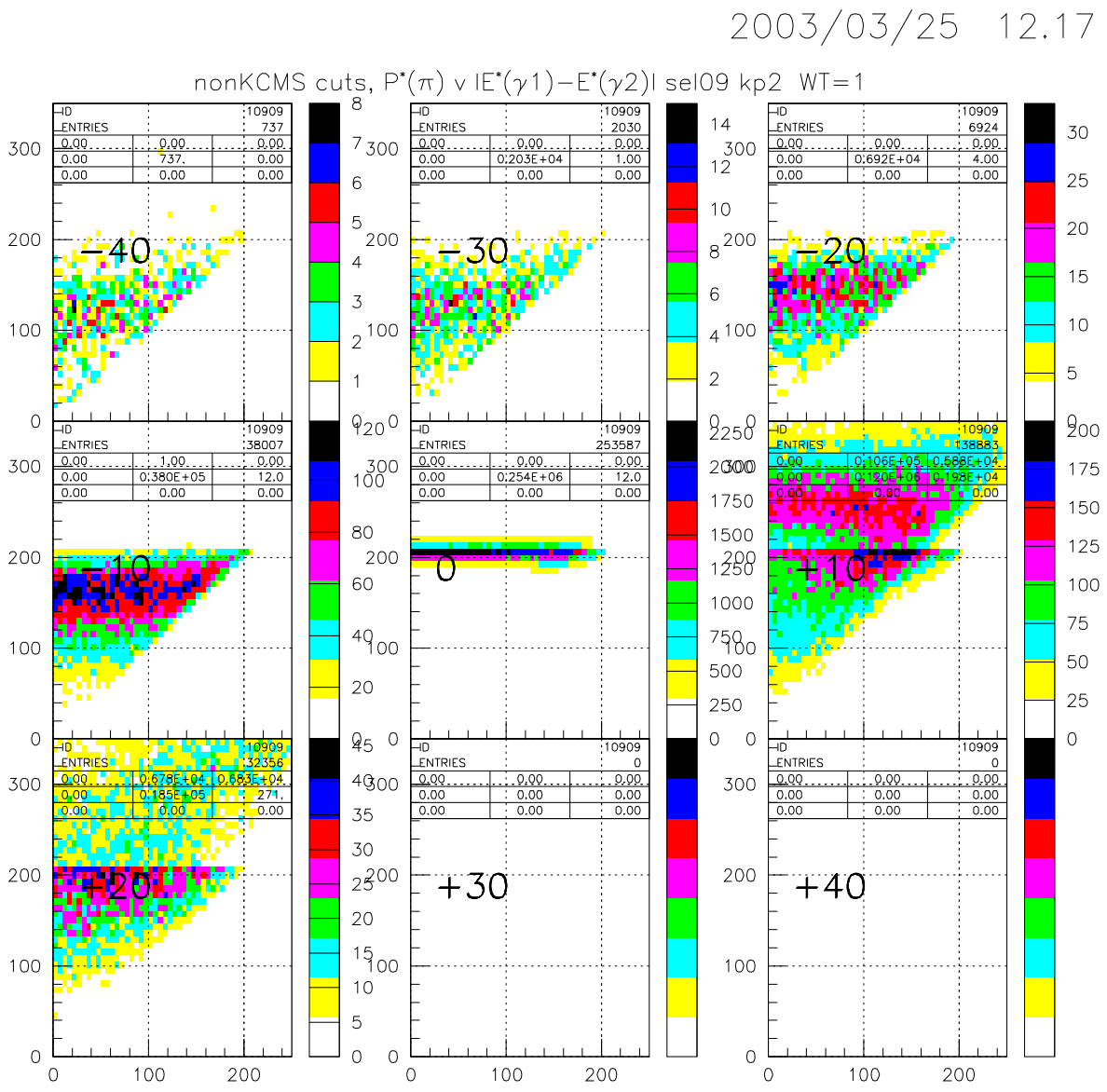

Figure 4: $P^*(\pi^0)$ *vs* $|E^*_{\gamma 1} - E^*_{\gamma 2}|$ distributions for the 9 different times with respect to the bunch.